Role of Computed Tomography in Evaluation of Traumatic Brain Injury and Correlation of Imaging Findings with Clinical Outcome

Dr. Prithu Raj[1], Dr. Prabhat Kumar[2]

[1]Post Graduate Resident, Department of Radiodiagnosis, Narayan Medical College, Jamuhar, Bihar, India
[2]Post Graduate Resident, Department of Radiodiagnosis, Narayan Medical College, Jamuhar, Bihar, India

Abstract: ***Introduction**: TBI is defined in this current paper context as damage or pathology only to the brain parenchymal/tissue caused by an external force (s), excluding injury of the skull or scalp. TBI may present with single or multiple pathoanatomic features in a patient even in a single trauma episode. The main external cause of head trauma, and consequently TBI are RTA (accounting for about 60% of cases), falls (20-30%), violence (10%), and work place and sports related activities. Epidemiologically, TBI is considered a very serious public health and socioeconomic problem, and is predicted to surpass many diseases as a major cause of death and disability by the year 2020. **Aims & Objectives**: 1. To assess the imaging characteristics of primary brain injury on CT scan post trauma 2. To evaluate these imaging features as predictors of clinical outcome in patients with traumatic brain injury. **Results**: A total of 75 patients with head injury were included in this study. The mean age at presentation was 40.08±12.45 years (range-18 to 70 years). The mean GCS of study subjects was 7.85±3.39.39 patients (45.9%) were noted to have moderate head injury and 46 (54.1%) had severe head injury.89.33% study subjects had SAH, 84% subjects had contusion, 64% subjects had SDH, 40% study subjects shows midline shift, 29.33% subjects shows EDH, 17.33% shows basal cisterns injury and 6.67% study subjects shows diffuse axonal injury. In our study out of 19 study subjects with GCS≤ 5, 10 subjects were alive whereas 9 subjects were dead, whereas higher GCS such as 6-10, had higher alive person i. e 27 out of 36, and GCS 11-15 had all alive person 20, on applying chi-square it was significant with p value-0.02. Conclusion On the basis of our study we can conclude that outcome of study subjects were positively associated with GCS score of study subjects as well as the CT findings of study subjects.***

Keywords: Head injury, traumatic brain injury, CT head, Trauma

1. Introduction

In several literatures the terms “head injury (HI) and traumatic brain injury (TBI)” have being used interchangeably. However, there are basis to disagree or vary in opinion. Anatomically the word “head” refers to a unit structure constituted by skull (i.e. bony and soft tissue of face and vault), scalp (immediate soft tissue covering of the skull) and brain (structure enclosed in the skull). Hence, HI can be defined as physical damage that may involve the skull and or scalp and or brain, but TBI cannot entail injury of the skull and or scalp. (1) Therefore, TBI is defined in this current paper context as damage or pathology only to the brain parenchymal/tissue caused by an external force (s), excluding injury of the skull or scalp. TBI may present with single or multiple pathoanatomic features in a patient even in a single trauma episode. The main external cause of head trauma, and consequently TBI are RTA (accounting for about 60% of cases), falls (20-30%), violence (10%), and work place and sports related activities (10%). Epidemiologically, TBI is considered a very serious public health and socio-economic problem, and is predicted to surpass many diseases as a major cause of death and disability by the year 2020. (2) Pathophysiology of TBI.

TBI pathogenesis is a complex process that results from primary and secondary injuries that lead to temporary or permanent neurological deficits. The primary deficit is related directly to the primary external impact of the brain. (3)

The secondary injury can happen from minutes to days from the primary impact and consists of a molecular, chemical, and inflammatory cascade responsible for further cerebral damage. This cascade involves depolarization of the neurons with the release of excitatory neurotransmitters such as glutamate and aspartate that lead to increased intracellular calcium. Intracellular calcium activates a series of mechanisms with the activation of enzymes caspases, calpases, and free radicals that results in degradation of cells either directly or indirectly through an apoptotic process. This degradation of neuronal cells is associated with an inflammatory response that further damages neuronal cells and incites a breach inthe blood brain barrier (BBB) and further cerebral edema. This entire process is up regulated and down regulated as well through several mediators. After the second injury phase follows the recovery period, which consists of reorganization in an anatomical, molecular, and functional level. (4)

Clinical examination remains the cornerstone of acute TBI assessment. There are numerous clinical classification systems for TBI based on symptomology and severity, the most entrenched of which is the Glasgow Coma Scale (GCS). (5)

TBI is a clinical diagnosis traditionally classified using the Glasgow Coma Scale (GCS). GCS scores 13-15 are mild brain injuries, 9-12 are moderate, and 3-8 are severe. There is a strong correlation between GCS score and morbidity and/or mortality at the severe end of the spectrum but limited correlation at the mild end of the spectrum. (6)

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The GCS has been a long-standing clinical tool used to quickly categorize TBI as mild, moderate, or severe solely on the basis of physical examination findings without the need to use specialized tools. GCS score is determined by summing the scores from three categories: best eye response (score 1-4), best verbal response (score 1-5), and best motor response (score 1-6), yielding scores of 3-8 (severe), 9-12 (moderate), and 13-15 (mild) (5). The value of this method has been its ease of use combined with the strong correlation to morbidity and mortality at the severe end of the TBI spectrum. (7)

In recent years, many researchers have emphasized the role of various forms of brain injury in producing neurocognitive deficits and neurobehavioral abnormalities. As a result, increased attention has turned to imaging evaluation of the head trauma patient. (8)

CT is the single most and primary modality in the evaluation of patients with acute head injuries [3, 4]. Conventional CT is more available, cost-effective, requires shorter imaging time and easy to perform on patients on ventilator support, in traction, oragitated is the initial imaging modality of choice during the first 24 h after the injury. Reduced time as well as evaluation the bone injuries are the additional advantages. (9)

2. Aims & Objectives

1. To assess the imaging characteristics of primary brain injury on CT scan post trauma
2. To evaluate these imaging features as predictors of clinical outcome in patients with traumatic brain injury.

3. Materials and Methods

A prospective observational study was performed on the patients visiting OPD with Traumatic brain injury. In this study we enrolled patients with TBI who presented to the emergency departments in Narayan medical college Jamuhar and were treated as per protocol.

The inclusion criterion

1. Study subjects who were 17 yr or older at the time of enrolment
2. Patients with traumatic brain injury who presented to hospital with a clinical indication for a head CT.

Exclusion criteria

1. The study subjects with pregnancy, incarceration, non survivable physical trauma, and pre existing medical or neuropsychiatric conditions that could interfere with outcome assessments.

GCS scores of 13 to 15 on emergency department arrival and an initial head CT available for review. it shows the recruitment and retention flowchart for the participants included in this analysis. It is a prospective observational study of patients with TBI presenting with the inclusion criteria and exclusion criteria. Data of all the patient following in the inclusion criteria during the period of study were elevated for NOC, Nexus-II and CCHR criteria as reported in other studies. The findings of the CT scan were evaluated by two blinded independent radiologists. The data regarding demographic information, history of the patient, cause of the trauma and CT findings were obtained for all the patients and recorded in the questionnaire, particularly designed for the research. The term petechial hemorrhage was used to describe small subcortical or deep hemorrhages that are the most common CT manifestation of the CDEs, traumatic axonal injury, and diffuse axonal injury. Statistical analysis was performed using SPSS version21, Quantitative variables were described as mean, median and standard deviation. Qualitative variables were presented as percentages and frequencies. The correlation between the variables was determined using logistic regression.

4. Results

A total of 75 patients with head injury were included in this study. The mean age at presentation was 40.08±12.45 years (range-18 to 70 years).

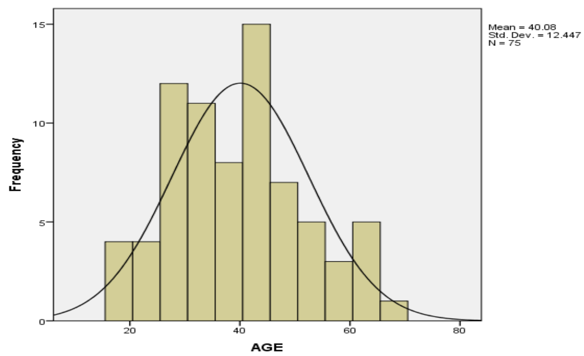

Figure 1: Distribution of study subjects as per age

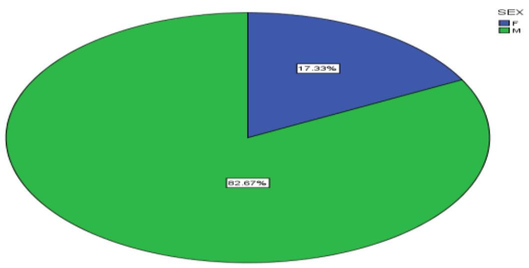

Figure 2: Distribution of study subjects as per age

62 patients (82.67%) were males and 13 (17.33%) were females.

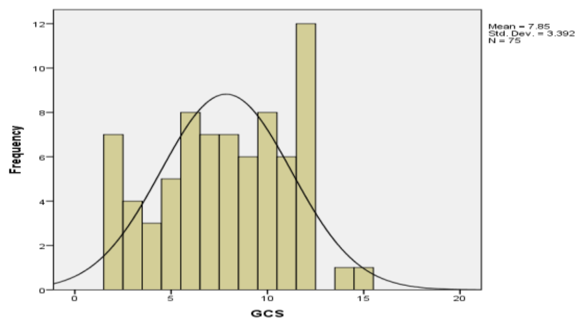

Figure 3: Distribution of study subjects as per GCS

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Figure 3 shows distribution of study subjects as per GCS, The mean GCS of study subjects was 7.85±3.39

Table 1: Major CT findings observed in patients with TBI

CT Findings	no	%
EDH	22	29.33
SDH	51	68.00
SAH	67	89.33
Contusion	63	84.00
IVH	11	14.67
Basal cisterns	13	17.33
Midline shift	30	40.00
Diffuse axonal injury	5	6.67

Table 1 showing major CT findings observed in patients with TBI, 89.33% study subjects had SAH, 84% subjects had contusion, 64% subjects had SDH, 40% study subjects shows midline shift, 29.33% subjects shows EDH, 17.33% shows basal cisterns injury and 6.67% study subjects shows diffuse axonal injury.

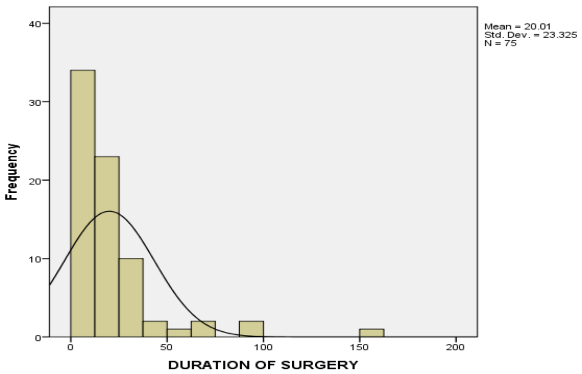

Figure 4: Distribution of study subjects as per time interval of trauma to injury

Figure 4 shows distribution of study subjects as per time interval of trauma to injury, the mean time interval of trauma to surgery was 20.01±23.32 day, with range 1-150 days.

Table 2: Association of GCS of study subjects with outcome

GCS	OUT COME					Total
	grade 1	grade 2	grade 3	grade 4	grade 5	
<5	8	2	0	1	8	19
6-10	23	2	3	1	7	36
11-15	17	3	0	0	0	20
Total	48	7	3	2	15	75
Chisquare value-5.29, p value-0.02, significant						

Table 2 shows Association of GCS of study subjects with outcome, 19 study subjects out of 75 were had GCS below 5, in which 8 subjects had grade 1 outcome, 8 subjects had grade 5. In 36 study subjects with GCS score 6-10, 23 study subjects had grade 1, 2 subjects had grade 2, 3 study subjects had grade 3, out of 20 study subjects 17 subjects had grade 1 outcome, on applying chi-square it was significant with p value 0.02.

Table 3: Association of GCS of study subjects with dead/alive condition of study subjects

		Dead/ alive		Total
		alive	death	
GCS	≤5	10	9	19
	6-10	27	9	36
	11-15	20	0	20
Total		57	18	75
Chi square value-5.29, p value-0.02, significant				

Table 3 shows Association of GCS of study subjects with dead/alive condition of study subjects, out of 19 study subjects with GCS≤ 5, 10 subjects were alive whereas 9 subjects were dead, whereas higher GCS such as 6-10, had higher alive person i. e 27 out of 36, and GCS 11-15 had all alive person 20, on applying chi-square it was significant with p value-0.02.

Images

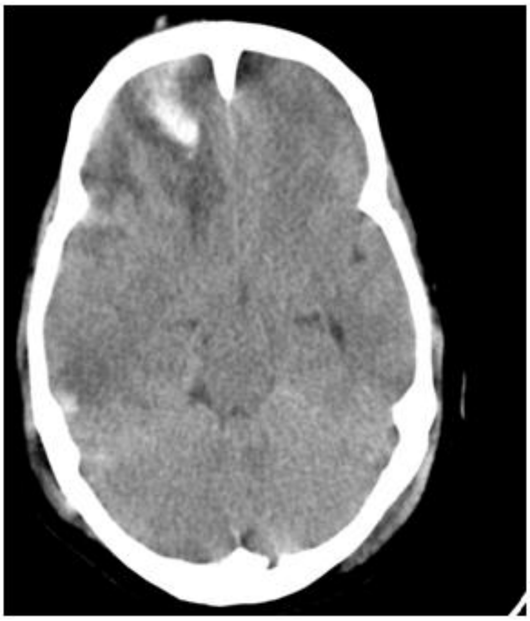

Figure 1: Diffuse axonal injury

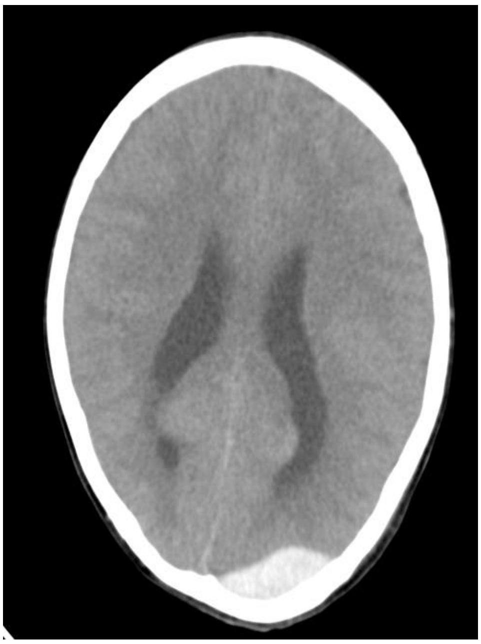

Figure 2: extradural hematoma

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Figure 3: left frontal lobe contusion

Figure 4: left temporal bone fracture

Figure 5: right frontal lobe contusion

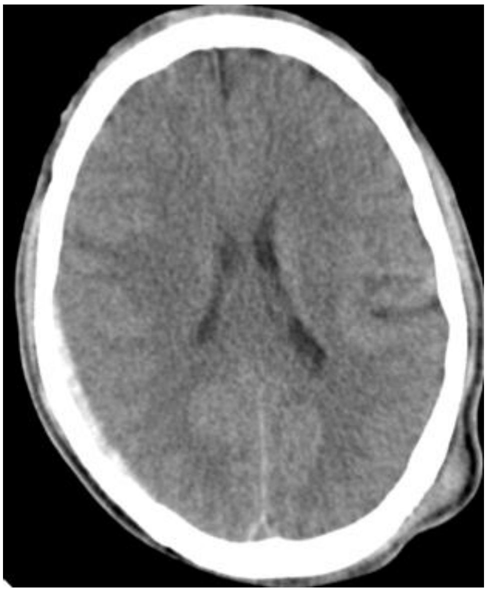

Figure 6: right parietal subdural hematoma

5. Discussion

AGE

In our study The mean age at presentation was 40.08±12.45 years (range-18 to 70 years). In a study by **Adam Ross Befeler** et al (2017) (10) the mean age of the population studied was 43 ± 19 years with a range between 15 and 87 years. In a study by **Djino Khaki** et al (2021) (11) the mean age was 59 years. In a study by **Dr Arun Kumar. V. B** et al (2014) (12) patients age were ranging from 16 to 70years. Out of 85 patients, 20-40yrs age group contributes maximum of 49patients.

GENDER

In our present study 62 patients (82.67%) were males and 13 (17.33%) were females. In a study by **Adam Ross Befeler** et al (2017) (10) there were 117 (63%) males and 68 (37%) females. In a study by **Djino Khaki** et al (2021) (11) 70%were male. In a study by **Dr Arun Kumar. V. B** et al (2014) (13) out of 85 patients, study sample consists of 71 male and 14female. In a study **Esther L. Yuh**et al (2021) positive head CT result was more likely in men (504 of 1286 men [39.2%]; 211 of 649 women [32.5%]; P =.004). In a study by **Hayford Kwakye Asare** et al (2019) (2) 77.4% of the patients were males while 22.6% were females, giving a male/female ratio of 3.4: 1.

GCS score

The mean GCS of study subjects was 7.85±3.39.39 patients (45.9%) were noted to have moderate head injury and 46 (54.1%) had severe head injury. In a study by **Adam Ross Befeler** et al (2017) (10) GCS score upon arrival ranged from 3 to 15 with a mean of 12 ± 3. Head injuries were severe (GCS Score 3-8) in 33 (18%) patients, moderate (GCS Score 9-12) in 33 (18%) patients, and mild (GCS Score 13-15) in 119 (64%) patients. In a study by **Djino Khaki** et al (2021) (11) in total, 60 patients presented with a severe TBI (38%), 43 patients

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with moderate TBI (27%) and 55 patients (35%) with mild TBI. In a study by **Dr Arun Kumar. V. B** et al (2014) (13) the mean GCS was 8 plus or minus 2 ranging from 1t012. A patient was considered to have severe head injury if GCS was 8or less which was observed in 46 patients and moderate head injury if GCS is between 12 to 9 which was observed in 39 patients.

CT Findings

89.33% study subjects had SAH, 84% subjects had contusion, 64% subjects had SDH, 40% study subjects shows midline shift, 29.33% subjects shows EDH, 17.33% shows basal cisterns injury and 6.67% study subjects shows diffuse axonal injury. In a study by **Adam Ross Befeler** et al (2017) (10) the types of intracranial abnormalities seen on initial CT imaging included acute subdural hematoma in 76 (41%) patients, chronic subdural hematoma in 2 (1%) patients, traumatic subarachnoid hemorrhage in 109 (59%) patients, intraparenchymalhemorrhage in 91 (49%) patients, intraventricularhemorrhage in 17 (9%) patients, epidural hematoma in20 (11%) patients, skull fracture in 74 (40%) patients, and pneumocephalus in 25 (14%) patients. In a study by **Djino Khaki** et al (2021) (11) acute subdural hematomas were the most predominant finding present in 85% of the patients. In a study by **Dr Arun Kumar. V. B** et al (2014) (13) out of 85 patients, extra duralhemorrhage were observed in 27patients, sub duralhemorrhage were observed in 60patients, Contusion were observed in 71patients.

Prognostic Factors

In our study out of 19 study subjects with GCS≤ 5, 10 subjects were alive whereas 9 subjects were dead, whereas higher GCS such as 6-10, had higher alive person i. e 27 out of 36, and GCS 11-15 had all alive person 20, on applying chi-square it was significant with p value-0.02. In a study by **Adam Ross Befeler** et al (2017) (10) at the time of follow-up, 132 patients (71%) exhibited clinical improvement, 50 (27%) patients were stable, and3 (2%) were clinically worse by history or examination. In a study by **Djino Khaki** et al (2021) (11) the results from the prognostic calculators IMPACT and CRASH yielded a favorable IMPACT score in 54.4% of the cohort, and a favorable CRASH score in 38.0%. GOS atone year after discharge showed good recovery in 15.8%, moderate disability in 27.2%, severe disability in 24.7%, and death in 29.7%. A study by **J M Wardlaw** et al (2001) (14) found a significant positive associations between survival at 12 months and pupil score; the presence of an EDH; and focal versus diffuse injury on the TCDB classification.

6. Conclusion

On the basis of our study we can conclude that outcome of study subjects were positively associated with GCS score of study subjects as well as the CT findings of study subjects.

7. Limitation

- In our study, we are not able to accomplish large population group due to loss of patients follow up and inadequate volume of cases (moderate to severe traumatic brain injury).
- Combination of individual imaging features not assessed.

Source of funding: No

Conflict of interest: No

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